

DETAILED DESCRIPTION OF THE INVENTION

(Field of Industrial Application)

The present invention pertains to a probe head and manufacturing method therefor.

(Prior Art)

A probe head used for testing the electrical characteristics of a semiconductor element such as an IC is generally constructed by preparing multiple probes made of hard material such as tungsten, arranging these probes so that their leading edges will correspond to the electrode pads on 4 edges of an IC, and by soldering the leading edges of the probes to a circuit board (e.g., Japanese Examined Patent Applications 54-43354 and 58-32783).

Therefore, the manufacture of such a probe head requires an extremely complex operation, wherein multiple probes are manually arranged on a supporting base; these multiple probes are secured to the supporting base by an adhesive; and the electrical connection of the leading edge of the probe is manually soldered.

(Problems of the Prior Art to Be Addressed)

As high integration of semiconductor chips such as an ICs increasingly advances, the pitch of electrode pads for the IC is increasingly minimized, and the number of the electrode pads is also dramatically increased.

Thus, the pitch of the electrode pads, which are the objects to be tested, is increasingly minimized, while on the other hand, the probe head is manufactured by

the prior art method, wherein multiple probes are arranged, positioned, bonded and soldered for every probe by a manual operation. With this prior art method, however, there is a limit to the minimizing the pitch of the probes. Also, there is a limit to the way of securing high positional accuracy while matching the minute pitch.

If such a probe head having the minute pitch and high positional accuracy is manufactured by the prior art manual method, a problem will arise that the manufacturing will require an extremely high cost since it requires a highly advanced technology.

The present invention was produced to solve such a problem of the prior art, and attempts to present a probe head having a minute pitch and high positional accuracy.

(Means to Solve the Problems)

The first invention is characterized in that, when a probe is formed on an insulated substrate, the end of a wire is bonded by ultrasonic wave bonding to the predetermined position of the conductive pattern section on said insulated substrate, and the wire is cut while being moved in the prescribed direction of the wire to form a whisker, which is then used as a probe.

The second invention is characterized in that, in the probe head, wherein the probe is installed on the insulated substrate, a metal bump is formed at the predetermined position of the conductive pattern on said insulated substrate, and

this metal bump is used as a probe.

The third invention is characterized in that, in the probe head, wherein the probe is installed on the insulated substrate, a hard metal film is formed on the contact section of the probe that is to be contacted with an object to be measured by the probe.

The fourth invention is characterized in that, in the probe head, wherein the probe is installed on the insulated substrate, said insulated substrate is bonded to a base board with an adhesive via a number of particulate spacers.

(Operation)

In the first invention, after the end section of the wire is bonded by ultrasonic bonding to the predetermined position of the conductive pattern on the insulated substrate, the wire is cut while being moved in the prescribed direction to form a whisker, and this whisker is used as a probe. Since the bonding with high positional accuracy using pattern recognition can be performed by using a preexisting wire bonding technology, the pitch of the whiskers as the probes can be minimized with high positional accuracy.

In the second invention, the metal bump is formed at the predetermined position of the conductive pattern section on the insulated substrate, e.g., by a plating method using a mask or by a method for crimping a metal piece, and this metal bump is used as a probe. Accordingly, the probes can be formed at minute pitch and high positional accuracy.

In the third invention, in the contact section of the probe that is to be contacted with an object to be measured, a hard metal film, e.g., rhodium, rubidium, platinum, or molybdenum film, is formed. Accordingly, the abrasion of the probe caused by the contact with the object to be measured is prevented, allowing the position data to be kept accurate for a long time. In the fourth invention, when the insulated substrate is bonded to the base board by an adhesive via the spacer composed of multiple particles with 5-15 μm , the thickness of the adhesive layer is made uniform, preventing the insulated substrate from being slantingly bonded, and thus the position accuracy of the probe is improved.

(Embodiment)

The embodiment example of the present invention is explained below with reference to the drawings.

Fig. 2 A, B, and C illustrate the steps of manufacturing the probe head of the wafer prober for testing the IC chip having the electrode pads on its four edges. In Fig. 2 A, the insulated substrate 10 is made of ceramic material or crystal sheet in circular form. In the center of this substrate 10, a circular through-hole is made. On the surface of this insulated substrate, narrow grooves 12 (that do not penetrate through the back surface) are made in radial direction.

The number of grooves 12 corresponds to the number of electrode pads on the 4 edges of IC (not shown in the figure).

Subsequently, as shown in Fig. 2 B, metal film layer 14 is formed inside each

groove made in said insulated substrate 10. This metal film layer 14 is formed nearly up to the same height as that of the surface of the insulated substrate 10 by sputtering chromium or plating gold. Thus, the electrode pattern is formed on the insulated substrate 10.

Subsequently, the probe is formed on said insulated substrate 10 by the characteristic process of the present invention.

For example, by the bonding head that holds the bonding wire, such as a gold wire, the first bonding is performed on the inner end section of said metal film layer 14 by using, e.g., ultrasonic wave vibration (See Fig. 1). Said first bonding can be performed in very short time, and no displacement occur after securing it, unlike the case wherein soldering is used, so the highly accurate positioning can be implemented.

In general wire bonding, after the first bonding has been performed, said bonding head is moved into one direction, and subsequently the second bonding is performed at other one point on the substrate (See the imaginary line in Fig. 1.).

In this embodiment example, to form the probe by this bonding step, the bonding head is moved toward the position corresponding to said electrode pad on the side of the center of said insulating substrate 10, and the moving speed of the bonding head is accelerated in the middle of this movement, whereby said bonding wire is cut in the middle of movement without performing the second bonding. When the wire is cut in the middle of the bonding head movement, the leading edge

f the wire results in a sharp end, as shown in Fig. 1, and thus whisker 20 shown in the figure is formed. In the embodiment example of the present invention, this whisker 20 is used as a probe.

As mentioned above, the aforementioned formation step of whisker 20 is repeatedly applied to the inner end section of each metal film layer 14 formed on the insulated substrate 10, and as a result, multiple whiskers 20 extending inward from the inner end of metal film layer 14 are formed as the probes (Fig. 2C).

When the aforementioned whiskers 20 are formed, a preexisting wire bonding technology can also be used as is.

More specifically, the pattern of each metal film layer 14, the bonding position of each pattern, and the moving direction for the second bonding are memorized; this standard pattern and the insulated substrate 10 to be wired are photographed by a TV camera; the outputs of the photographs are compared by using a pattern recognition technology to detect an error; and the probe is automatically attached by moving the position of the insulated substrate 10.

Therefore, even if the arrangement pitch of said metal film layers 14 is minute, the position of the inner end of metal film layer 14 can be easily recognized by the pattern recognition device, and by using the result of this recognition, the bonding head can be controlled to move. Thereby, the probes, in other words, whiskers 20, that are arranged at minute pitch can be easily manufactured.

The probe head thus manufactured is repeatedly used for testing multiple

objects to be tested (IC), so it needs to have a specific level of durability. In the aforementioned embodiment example, however, a gold wire is used as a wire for forming the whisker 20, so the whisker lacks durability.

Therefore, it is desirable that a hard metal film is formed on the whisker 20 by electroplating of a metal after the aforementioned whisker 20 has been formed, in order to increase the abrasion-resistance and mechanical strength. As for the plating material, rhodium, rubidium, platinum, and molybdenum can be cited.

As shown in Fig. 3, the probe head thus manufactured supports and secures the semiconductor wafer 32 above the holding table 30, and when the tip end of the whisker 20 is contacted with the electrode pad of each IC on the wafer 32, the electrical characteristics of the IC are tested.

Since the whisker 20 has a specific level of elasticity, even if the holding plate 30 is over-driven, the probe head can definitely contact with each electrode pad on the IC with a specific pressure level due to elastic deformation of the whisker. In this example, the metal film layer 14 is at the equal plane to the surface of the insulated substrate 10, allowing to secure a space so that metal film layer 14 will not contact with the electrode pad of other IC on the semiconductor wafer 32.

In the present invention, by controlling the bonding head to move, the whisker 20 can be formed in any direction and at any position on the insulated substrate and, also, random arrangement which was difficult in the past can become possible. Accordingly, even if the probes are arranged in two rows or in zigzag

form, these random arrangements can be easily achieved by the probe head manufacturing method of the present invention.

Fig. 4 illustrates the structure of another probe head for testing the IC. As shown in Fig. 4, metal film layer 14 may be formed in parallel to the orthogonal coordinates on the insulated substrate 10, and multiple whiskers 20 may be arranged in parallel to the length direction of the metal film layer 14.

Also, in the aforementioned embodiment example, the metal film layer is formed to have an equal height to that of the insulated substrate 10. The reason for this is to prevent the metal film layer 14 from contacting with the other IC on the semiconductor wafer 32, but it is also possible that metal film layer 14 with a specific thickness is directly formed on the insulated substrate 10 without making the groove 12 as in the aforementioned embodiment. To reinforce the strength of the whisker 20 formed by the wire bonding process, the hard metal film is formed on the whisker 20 in the aforementioned embodiment example, but this hard metal film is not necessarily needed depending upon the types of the bonding wire.

The second embodiment example is explained below with reference to Fig. 5 and Fig. 9.

The insulated substrate 101 is made of elastically deformable material, e.g., ceramic or crystal material, into a fan shape. On its one end, probes 103 formed in comb shape are made at minute pitch corresponding to the pitch of electrode pad 203 of the IC formed on the wafer 201. On the other surface of the insulated

substrate 101, the conductive pattern 105 is formed in radial direction toward the other end of said probe 103 from its leading edge. On the other hand, as shown in Fig. 6, grounding pattern 107 is formed over the other surface, constituting a micro strip line structure.

The aforementioned conductive pattern 105 is structured by depositing a metal having affinity with the insulated substrate 101, e.g., a chromium layer, as a wetting material up to a 50 nm thickness by sputtering, subsequently depositing a metal having affinity with the chromium layer, e.g., gold layer 111, up to a 50 nm thickness by sputtering, and finally, by forming the conductive layer 113 made of excellent conductive material, e.g., gold, silver, or copper, up to a nearly 5 μm thickness by electroplating.

Moreover, on the conductive pattern 105 at the leading edge of probe 103, metal bump 115 made of gold is formed by, e.g., a method for thermally crimping a metal piece or by an electroplating method.

More specifically, the bumps 115 are made correspond to the electrode pads 203 of the IC, and by the contact of the bumps 115 with the electrode pads 203, electrical conduction is obtained, as in the case of the prior art probe head and probe. These bumps can be formed at minute pitch and high positional accuracy by a method for crimping a metal piece or by an electroplating method using a mask.

On the bump 115, to reinforce the mechanical strength and abrasion-resistance, a hard metal film is formed (not shown in the figure), as in the

aforementioned first embodiment example.

As shown in Fig. 8, in the aforementioned insulated substrate 101, a probe head is structured by bonding multiple sheets, e.g., 4 sheets, from 4 edges of rectangular through-hole 303 made in the center of substrate 301 facing the through-hole 303. Then, as shown in Fig. 5, flexible print circuit board 305 having the conductive pattern corresponding to the conductive pattern 105 of the insulated substrate 101 is connected to the outer end of the insulated substrate 101, and via this flexible printed circuit board 305, the tester (not shown in the figure) and the conductive pattern 105 of the insulated substrate 101 are connected. Then, as in the aforementioned embodiment example, bump 115 formed on the conductive pattern 105 at the leading edge of the probe 103 is brought into contact with the electrode pad 203 of the IC of wafer 201, and electrical testing of the IC is conducted by the tester.

As explained above, the insulated substrate 101 has a micro strip line structure having the conductive pattern 105 on one surface and the grounding pattern 107 on the other surface, but the flexible printed circuit board 305 also has a micro strip line structure with an impedance match.

Also, the aforementioned insulated substrate 101 and the base board 301 are bonded by, e.g., by adhesive 40, in which is diffused a number of particulate spacers 401 made of hard plastic material and having diameter nearly 5-15 μm , e.g., "Micro Pearl SP" (product name by Sekisui Fine Chemical Corporation), as shown in Fig. 9.

This is to prevent the insulated substrate 101 from being slantingly secured to the base board 301 without forming a uniform thickness of the adhesive between the insulated substrate 101 and the base board 301.

If the insulated substrate 101 is slantingly secured to the base board 301, the height of the contact surface of the bump 115 will be uneven when the bump 115 is brought into contact with the electrode pad 203 of the IC, as shown in Fig. 5, and the bump 115 and the electrode pad 203 of the IC cannot be contacted with each other with uniform pressure. When the pressure of contacting the bump 115 with the electrode pad 203 of the IC is uneven, electrical resistance is increased in the area where the contact pressure is weak, so the accurate measurement cannot be performed.

Therefore numerous particulate spacers 401 are inserted between the insulated substrate 101 and the base board 301 to make the adhesive layer 403 have an even thickness; accordingly, by keeping the insulated substrate and the base board 301 nearly in parallel, each bump 115 and the electrode pad 203 are brought into contact with each other with uniform pressure, and accurate measurement can be performed.

The present invention is not limited to the aforementioned embodiment examples, but variant forms are possible within the scope of the principle of the present invention.

(Advantage)

As explained above, according to the present invention, a probe head can be manufactured at higher pitch and higher positional accuracy than the prior art.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a schematic diagram of the key components of the probe head as the embodiment example of the present invention. Fig. 2 shows a schematic diagram of the probe head of Fig. 1 in its manufacturing steps. Fig. 3 shows a schematic diagram illustrating the state of testing the electrical characteristics by using the probe head of Fig. 1. Fig. 4 shows a schematic diagram of the whisker in variant form arranged on the insulated substrate. Fig. 5 - Fig. 9 show a schematic diagram of the probe head as the second embodiment example.

10. Insulated substrate

12. Groove

14. Metal film layer

20. Whisker (probe)